Excess Physical Limitations Among Adults With Diabetes in the U.S. Population, 1997–1999

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OBJECTIVE — To estimate the prevalence of physical limitations associated with diabetes among U.S. adults ≥18 years of age.

RESEARCH DESIGN AND METHODS — We conducted a cross-sectional analysis of the association between diabetes status and physical limitations using the 1997–1999 National Health Interview Survey (NHIS). Physical limitation was defined from self-reported degree of difficulty with nine tasks.

RESULTS — People with diabetes had a higher proportion of any physical limitation than did people without diabetes overall (66 vs. 29%, $P < 0.001$), for both men (59 vs. 24%, $P < 0.001$) and women (72 vs. 34%, $P < 0.001$). Compared with those without diabetes, a higher proportion of people with diabetes had some physical limitation among all age groups, and the difference declined (all $P < 0.001$) with increasing age (46 vs. 18% for 18–44 years, 63 vs. 35% for 45–64 years, 74 vs. 53% for 65–74 years, and 85 vs. 70% for those 75 years and older). After controlling for demographic characteristics and several other confounders, the odds ratio of physical limitation among adults with diabetes versus those without diabetes was 1.9 (95% CI: 1.8–2.1).

CONCLUSIONS — People with diabetes are much more likely to have a physical limitation than those without diabetes. Interventions are needed in this population to reduce progression from impairment to physical limitation and from physical limitation to disability, especially because the prevalence of diabetes is projected to increase dramatically in the next several decades.

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Diabetes is a costly chronic condition associated with a wide range of complications and comorbidities, including cardiovascular disease, peripheral vascular disease, vision loss, and peripheral neuropathy (1–3). The association between diabetes and disability has not been well studied, but some researchers have found that disability is two to three times higher among people with diabetes than among those without diabetes (3–6). Disability is a key indicator of the degree of morbidity associated with a chronic disease such as diabetes and a core component of the impact of chronic disease on quality of life. Previous studies of diabetes and disability have focused on disability in very general terms and have not examined the types and prevalence of limitations in those physical tasks that often lead to disability. In 1997, nine questions measuring physical limitations based on Nagi and Marsh and Rosow and Breslau (7–9) were added to the National Health Interview Survey (NHIS). In this study, we use these questions to estimate the prevalence of physical limitations among U.S. adults ≥18 years of age with diabetes and to compare the prevalence of physical limitations in people with and without diabetes.

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Abbreviations: NHIS, National Health Interview Survey.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

RESEARCH DESIGN AND METHODS

Data source

We analyzed data from the 1997–1999 NHIS, an ongoing nationally representative household survey providing self-reported information on the noninstitutionalized U.S. civilian population (10). The survey focuses on demographic information, current health conditions, health status and limitation of activities, and health behavior. Our analysis included data on 99,357 respondents ≥18 years of age who completed the sample adult interview between 1997 and 1999.

Assessment of diabetes and physical limitations

Participants were asked whether they had ever been told by a doctor or other health professional that they had diabetes or "sugar diabetes." Those reporting borderline diabetes and women who had diabetes only during pregnancy were categorized as not having diabetes. The sample included 5,829 people with diabetes and 93,273 without diabetes (and 255 people with a missing response to the diabetes question), representing an annual average of 10.3 million individuals with diabetes and 186.6 million individuals without diabetes.

Respondents were asked questions about their ability to perform nine physical tasks, as follows: "By yourself, and without using any special equipment, how difficult is it for you to. . . . " "walk a quarter mile" (walking); "walk up 10 steps without resting" (climbing); "stand or be on your feet for about 2 h" (standing); "sit for about 2 h" (sitting); "stoop,

bend, or kneel" (stooping); "reach over your head" (reaching); "use your fingers to grasp or handle small objects" (grasping); "lift or carry something as heavy as 10 pounds, such as a full bag of groceries" (carrying); and "push or pull large objects like a living room chair" (pushing). Responses were classified as 0 (not difficult at all), 1 (only a little difficult), 2 (somewhat difficult), 3 (very difficult), and 4 (can't do at all).

Covariates

Covariates included self-reported sociodemographic variables, risk factors, and health conditions believed to be associated with physical limitation or diabetes. The variables included sex, race/ethnicity (non-Hispanic black, non-Hispanic white, Hispanic, other), age (18–44, 45–64, 65–74, 75+ years), education (<12 years, 12 years, >12 years), marital status (married, single), smoking status (never, former, current), alcohol consumption (never, former, current), physical activity (light or moderate activity at least 10 min a day, none). We classified BMI (self-reported weight in kilograms divided by self-reported height in meters, squared) into underweight (BMI <18.5), normal weight (BMI between 18.5 and 24), overweight (BMI between 25 and 29), and obese (BMI ≥30 or greater). The following variables were dichotomized: hearing loss (any trouble hearing); vision loss (any trouble seeing even when wearing glasses or contact lenses); depression (feelings that interfered with life or activities in past 30 days); cardiovascular disease (including physician diagnosed coronary heart disease, angina, myocardial infarction, stroke, other heart disease, and hypertension); headache or migraines (in past 3 months); pain (any neck or back pain in past 3 months or joint pain in past 12 months); weak or failing kidneys (physician diagnosed in past 12 months).

Statistical analyses

Because of the complex sample design, we used SUDAAN (11) to test for significant differences, calculate confidence intervals, and perform bivariate and multivariate analyses. We examined associations between the covariates and diabetes status and between the covariates and physical limitation status. We also examined each of the nine tasks by diabetes status and sex, focusing on the prevalence of these tasks among people with diabetes. For each of the nine measures, "any limitation" was defined as a response >0 (no difficulty), inability to perform the activity (a response of 4—can't do at all), and some difficulty (a response of 1, 2, or 3—a little difficult, somewhat difficult, or very difficult). In overall comparisons between populations with and without diabetes, we defined "any limitation" as a response >0 for any of the nine measures.

We used proportional odds regression to estimate the association between diabetes and five ordinal levels of a physical limitation summary score (sum of the responses to the nine questions), while controlling for the covariates. People with no limitation on any measure had a summary score of 0, and higher scores reflected worse functioning. Among respondents with any limitation (i.e., those with a summary score >0), we evenly distributed summary scores into four groups (i.e., quartiles): group 1 (score of 1–2), group 2 (score of 3–6), group 3 (score of 7–15), and group 4 (score of 16–36). The standardized Cronbach's alpha in this study was 0.927 for the nine physical limitation questions.

The proportional odds regression model assumes that the association between the exposure (diabetes status) and the outcome (physical limitation) is constant at all levels of the outcome variables. We assessed this assumption by calculating an adjusted odds ratio for each of four separate cut-points in the five ordinal levels of the summary score and found no difference in odds ratios.

RESULTS

— With the exception of sex and marital status, all sociodemographic, risk factor, and comorbidity characteristics differed by diabetes status. People with diabetes were more likely (all $P < 0.001$) than those without diabetes to be aged 65 years or older (41 vs. 15%), obese (41.9 vs. 18.8%), black (16.5 vs. 10.7%), and physically inactive (49.8 vs. 40.4%). They were also more likely (all $P < 0.001$) to have hearing loss (32.0 vs. 16.1%), symptoms of depression (27.3 vs. 16.9%), cardiovascular disease (70.7 vs. 26.3%), vision loss (24.8 vs. 8.3%), and neck/back/joint pain (63.8 vs. 46.0%). Compared with people without diabetes, those with diabetes were less likely (all $P < 0.001$) to have a high school education (33.1 vs. 17.8%,), to be current smokers (17.8 vs. 24.5%), and to be white (67.4 vs. 74.8%).

Overall, the proportion of people reporting a physical limitation for any of the nine tasks was greater among women than men (36 vs. 26%, $P < 0.001$) and greater among people with diabetes than those without diabetes (66 vs. 29%, $P < 0.001$). The proportion with any limitation on any of the nine tasks was higher for people with diabetes than for those without diabetes for all demographic, risk factors, and comorbidity characteristics. Both men (59 vs. 24%, $P < 0.001$) and women (72 vs. 34%, $P < 0.001$) with diabetes had higher levels of any limitation compared to those without diabetes. People with diabetes reported higher levels (all $P < 0.001$) of any limitation compared to those without diabetes in each age group (46 vs. 18% for those 18–44 years, 63 vs. 35% for those 45–64 years, 74 vs. 53% for those 65–74 years, and 85 vs. 70% for those 75 years and older), and differences narrowed with increasing age.

For each of the nine tasks, the percentage of people with any limitation was greater among women than men ($P < 0.0.001$) and among people with diabetes than those without diabetes ($P < 0.001$). In general, the percentage of people without diabetes who had any limitation was about one-third of that of people with diabetes.

Among women with diabetes, between 51 and 57% experienced some degree of difficulty (e.g., response >0) in stooping, standing, and walking; between 40 and 49% experienced some degree of difficulty in pushing, climbing, and carrying; and between 23 and 27% experienced some difficulty in sitting, reaching, and grasping (Fig. 1). These percentages were somewhat lower for men with diabetes but still high: between 40 and 44% experienced some difficulty in stooping and standing; between 29 and 38% experienced some difficulty in walking, climbing, and pushing; and between16 and 21% experienced difficulty in carrying, sitting, reaching, and grasping.

For each of the nine physical activities, the prevalence of not being able to perform it was greater among women than among men with diabetes (Fig. 1). Among women with diabetes, between 21 and 23% reported not being able to walk, stand, and push; between 13 and 17% were unable to stoop, climb, and carry; and between 2 and 4% were unable to reach, sit, and grasp. Among men with diabetes, between 12 and 15% reported

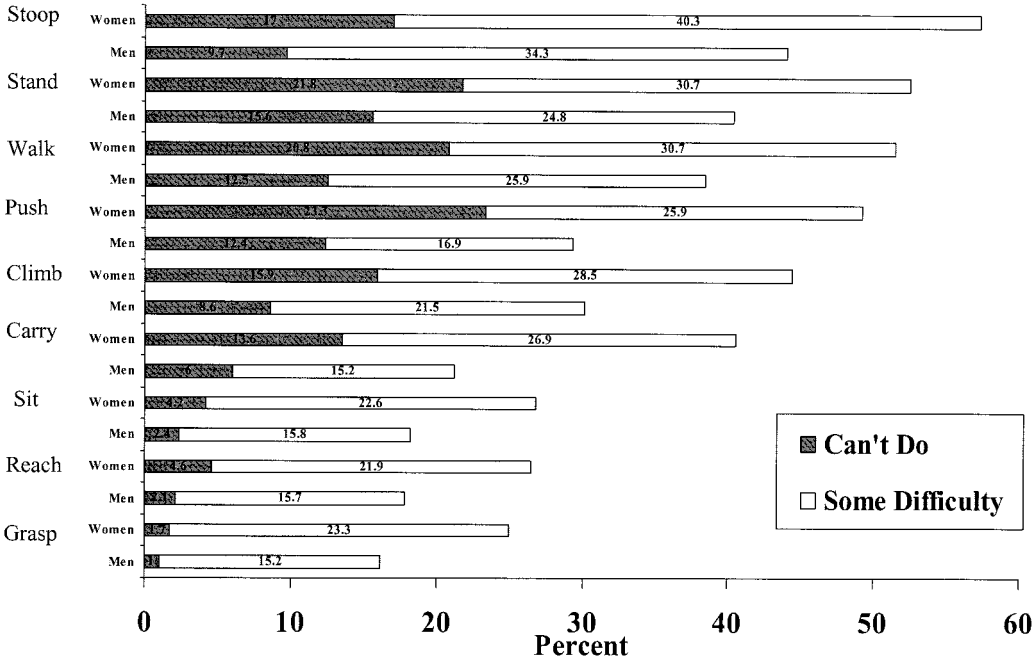

Figure 1—*Level of difficulty in physical limitation for nine tasks among women and men with diabetes, NHIS, 1997–1999.*

not being able to stand, walk, and push; between 6 and 9% were unable to stoop, climb, and carry; and between 1 and 2% were unable to sit, reach, and grasp.

The distribution of the physical limitation summary score by diabetes status is displayed in Fig. 2. The proportion of people with nonzero summary scores was greater among people with diabetes than among people without diabetes, and differences by diabetes status increased as scores increased, indicating a greater severity of limitation among people with diabetes. Among people with diabetes, 11.6% had a score of 1–2, with the percentage increasing to 24.7% for a score of 16–36. Among people without diabetes, the percentages decreased from 10.2% with a score of 1–2 to 5.3% for a score of 16–36.

The results of the ordinal regression models are shown in Fig. 3. The unadjusted odds for the association between physical limitation and diabetes status was 5.18 (95% CI: 4.87, 5.50) (model 1). Controlling for age reduced the odds to 3.2 (95% CI: 3.0, 3.41) (model 2). Adding the other demographic variables (i.e., education, race, sex) had little further impact (3.12; 95% CI: 2.93, 3.32) (model 3). Controlling for all previously mentioned demographic variables and for the risk factor variables (i.e., BMI, smoking) reduced the odds to 2.6 (95% C.I: 2.5, 2.8) (model 4). After adjusting for all the variables of interest, including comorbidities (i.e., hearing loss, depression, cardiovascular disease, neck/back/joint pain, vision loss), the odds ratio was 1.94 (95% CI: 1.81, 2.08) (model 5) for the association between physical limitation and diabetes status.

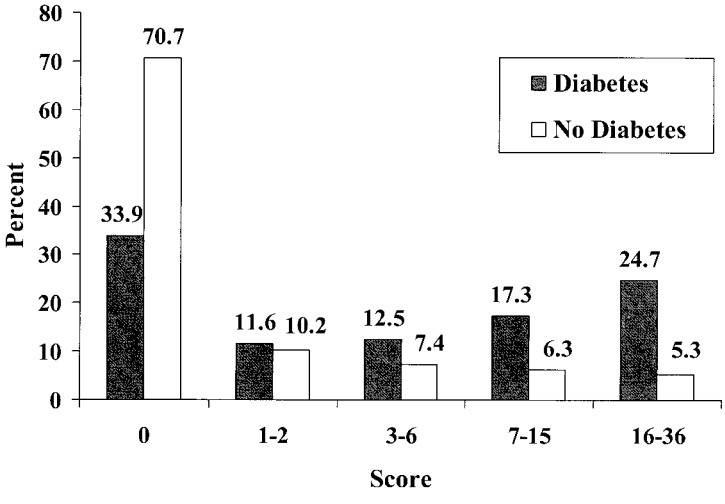

Figure 2—*Distribution of physical limitation summary score by diabetes status, NHIS, 1997–1999.*

CONCLUSIONS — In this nationally representative sample of U.S. adults, 66% of adults with diabetes (6.9 million people) had difficulty doing at least one of the physical tasks that we assessed. Those tasks involving mobility or lower extremity function, such as stooping, standing, walking, pushing, and climbing, tended to be the most problematic for people with diabetes and had the highest prevalence of any limitation. The prevalence of any limitation in activities likely to involve both lower and upper extremity function, such as pushing and carrying, was also high. Pushing, walking, and standing were the three activities for

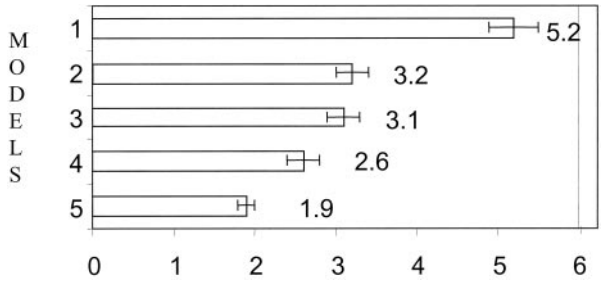

Figure 3—*Odds ratio for diabetes from the proportional odds models for five ordinal levels of the physical limitation summary score, NHIS, 1997–1999. Model 1, unadjusted; model 2, adjusted for age; model 3, adjusted for age, race, sex; model 4, adjusted for age, race, sex, BMI, smoking; model 5, adjusted for age, race, sex, BMI, smoking, hearing loss, depression, cardiovascular disease, neck/back/joint pain, vision loss.*

which individuals with diabetes had the highest prevalence of being unable to perform. Physical activities with the lowest prevalence of any limitation and of being unable to perform were sitting and two activities involving the upper extremity functions, grasping and reaching. Although the prevalence of any limitation in these activities was not inconsequential (ranging from 16 to 27%), the prevalence of being unable to perform these activities was low (ranging from 1 to 5%).

The high prevalence of limitations in lower extremity functioning found in this study are of concern because other studies have suggested that impairments in lower extremity physical functioning are key contributors to loss of physical independence and thus to disability (12–13). The high prevalence of lower extremity limitations in our nationally representative data highlights the need to preserve lower extremity function among people with diabetes.

The unadjusted odds ratio for the association between diabetes status and physical limitation was reduced by controlling for age (a decrease from 5.18 to 3.2), demonstrating that the older age of the diabetes population accounts for a large proportion of their increased risk of physical limitation. Because the U.S. population is aging, because the risk of diabetes increases with age, and because diabetes is becoming more prevalent, it is likely that the number of people with diabetes who are at risk for developing physical limitations and disability will increase dramatically over the next few decades.

Our data also show that people with diabetes have a higher prevalence of risk factors (e.g., are more obese and less physically active) and have a higher prevalence of health conditions (e.g., are more likely to have vision loss, depression, and cardiovascular disease) that are also associated with physical limitation compared with people without diabetes. After controlling for these risk factors and health conditions, the age-adjusted odds ratio of the association between physical limitation and diabetes status decreased from 3.1 to 1.94. This decrease highlights the multifactorial nature of activity limitation among people with diabetes and the need for risk factor reduction and complication prevention in order to reduce physical limitation among people with diabetes. However, after controlling for well-known risk factors and comorbidities, our findings indicate that diabetes was associated with about twice the odds of having physical limitations and suggest that other risk factors and health conditions not controlled for in our analysis, such as hyperglycemia, peripheral vascular disease, and peripheral neuropathy, may be involved.

Although a large proportion of both men and women with diabetes experienced some form of physical limitation in our study, women disproportionately reported more limitation in physical function. This is consistent with other studies in both the general and diabetic populations that have found greater prevalence of functional problems and disability among women (3,14–16). At least one study suggests that men and women accurately report their disability and that the higher prevalence of physical limitations in women truly reflects higher levels of disability (17). The reasons for this greater prevalence of disability and functional limitation among women are poorly understood, and more research is needed in this area (18).

Two strengths of our study are that we analyzed nationally representative data to estimate physical limitations and that we assessed limitations in specific physical activities by level of difficulty and constructed a summary score that reflected this level of difficulty.

Our study has several limitations. First, as with cross-sectional studies generally, it is difficult to ascertain temporality, and disability may have preceded diabetes rather than the reverse. To date, no prospective studies have examined whether physical disability hastens the development of diabetes. However, some studies have associated diabetes with a more rapid onset of disability (12). Second, our results apply only to the population living in the community. Exclusion of institutionalized individuals may have caused an underestimation of the overall prevalence of physical limitation and may have affected sex differences in physical limitation. Third, while self-reported diabetes has been shown to be a reliable measure of diagnosed diabetes (19,20), about one-third of all people with diabetes have not been diagnosed (21). In this analysis, people with undiagnosed diabetes were classified as not having diabetes and this may have biased the results.

This study of U.S. adults shows that diabetes is associated with increased physical limitation. In general, self-reported physical limitations predict future declines in health status, greater likelihood of institutionalization, increased health service use, and increased risk of mortality, as well as serious reductions in quality of life (22–24). Thus, the results of this study may have implications for preventing physical limitation and disability. Potential strategies to limit disability in people with diabetes include specialized lower extremity strength and balance training, walking, and tai chi, which have all been shown effective in maintaining muscle mass, preventing falls, and maintaining physical functioning (3,25,26). In addition, adults with diabetes should exercise; maintain weight; manage blood lipids, blood pressure, and blood glucose; use aspirin; and practice preventive foot and eye care to improve long-term physical functioning (3,27–31).

Public health implications

Diabetes is a common, costly disease in the U.S. that increases the risk of physical limitation. The burden of diabetes is projected to increase from 4% of the U.S. population in 2000 (~11 million people) to 7.2% in 2050 (almost 29 million people) (32). This growth, combined with the aging of the general population, suggests that the number of people at risk for physical limitations and disability will increase dramatically. The primary prevention of diabetes and the prevention of complications and comorbid conditions among people with diabetes will be necessary to help reduce the burden of physical limitation and disability. Further studies are needed to identify factors and interventions that will help delay or prevent the progression from diabetes to physical limitation and on to disability.

References

1. Nathan DM: Long-term complications of diabetes mellitus. *N Engl J Med* 328: 1676–1685, 1993
2. The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus: Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care* 25 (Suppl. 1):S5–S20, 2002
3. Gregg EW, Beckles GLA, Williamson DF, Leveille SG, Langlois JA, Engelgau MM, Narayan KMV: Diabetes and physical disability among older U.S. adults. *Diabetes Care* 23:1272–1277, 2000
4. Songer TJ: Disability in diabetes. In *Diabetes in America.* 2nd ed. Harris MI, Cowie CC, Stern MP, Boyko EJ, Reiber GE, Bennett PH, Eds. Washington, DC, Department of Health and Human Services, 1995 (NIH pub. no. 95–1468)
5. Gregg EW, Yaffe K, Cauley JA, Rolka DB, Blackwell TL, Narayan KMV, Cummings SR: Is diabetes associated with cognitive impairment and cognitive decline among older women? Study of Osteoporotic Fractures Research Group. *Arch Intern Med* 160:174–180, 2000
6. Mayfield JA, Deb P, Whitecotton L: Work disability and diabetes. *Diabetes Care* 22: 1105–1109, 1999
7. Nagi SZ, Marsh J: Disability, health status, and utilization of health services. *Int J Health Serv* 10:657–676, 1980
8. Rosow I, Breslau N: A Guttman health scale for the aged. *J Gerontol* 21:556–559, 1966
9. Nagi SZ: An epidemiology of disability among adults in the United States. *Milbank Memorial Fund Quarterly-Health and Society* 54:439–467, 1976
10. National Center for Health Statistics: Data file documentation, *National Health Interview Survey, 1997–1999* (machine-readable data file and documentation). Hyattsville, MD, U.S. Department of Health and Human Services, Public Health Services, National Center for Health Statistics, 1997–1999
11. Shah BV, Barnwell BG, Bieler GS: *SUDAAN User's Manual*. Release 7.5. Research Triangle Park, NC, Research Triangle Institute, 1997
12. Gregg EW, Mangione CM, Cauley JA, Thompson TJ, Schwartz AV, Ensrud KE, Nevitt MC: Diabetes and incidence of functional disability in older women. *Diabetes Care* 25:61–67, 2002
13. Volpato S, Blaum C, Resnick H, Ferrucci L, Fried LP, Guralnik JM: Comorbidities and impairments explaining the association between diabetes and lower extremity disability: The Women's Health and Aging Study. *Diabetes Care* 25:678–683, 2002
14. Leveille SG, Penninx BW, Melzer D, Izmirlian G, Guralnik JM: Sex differences in the prevalence of mobility disability in old age: the dynamics of incidence, recovery, and mortality. *J Gerontol B Psychol Sci Soc Sci* 55B:S41–S50, 2000
15. Guralnik JM, Leveille SG, Hirsch R, Ferrucci L, Fried LP: The impact of disability in older women. *J Am Women's Assoc* 52: 113–120, 1997
16. Geiss LS (Ed.): *Diabetes Surveillance, 1999*. Atlanta, GA, Centers for Disease Control and Prevention, U.S. Dept of Health and Human Services, 1999
17. Merrill SS, Seeman TE, Kasl SV, Berkman LF: Gender differences in the comparison of self-reported disability and performance measures. *J Gerontol A Biol Sci Med Sci* 52:M19–M26, 1997
18. Sowers M, Pope S, Welch G, Sternfeld B, Albrecht G: The association of menopause and physical functioning in women at midlife. *J Am Geriatr Soc* 49:1485–1492, 2001
19. Martin LM, Leff M, Calonge N, Garrett C, Nelson DE: Validation of self-reported chronic conditions and health services in a managed care population. *Am J Prev Med* 18:215–218, 2000
20. Robinson JR, Young TK, Roos LL, Gelskey DE: Estimating the burden of disease: comparing administrative data and self-reports. *Med Care* 35:932–947, 1997
21. Harris MI, Flegal KM, Cowie CC, Eberhardt MS, Goldstein DE, Little RR, Wiedmeyer HM, Byrd-Holt DD: Prevalence of diabetes, impaired fasting glucose, and impaired glucose tolerance in U.S. adults: The Third National Health and Nutrition Examination Survey 1988–1994. *Diabetes Care* 21:518–524, 1998
22. Tinetti ME, Inouye SK, Gill TM, Doucette JT: Shared risk factors for falls, incontinence, and functional dependence: unifying the approach to geriatric syndromes. *JAMA* 273:1348–1353, 1995
23. Nevitt MC, Cummings SR, Kidd S, Black D: Risk factors for recurrent nonsyncopal falls: a prospective study. *JAMA* 261: 2663–2668, 1989
24. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Scherr PA, Wallace RB: A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admissions. *J Gerontol A Biol Sci Med Sci* 49:M85–M94, 1994
25. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Tilyard MW, Buchner DM: Randomised controlled trial of a general practice program of home based exercise to prevent falls in elderly women. *BMJ* 315:1065–1069, 1997
26. Province MA, Hadley EC, Hornbrook MC, Lipsitz LA, Miller JP, Mulrow CD, Ory MG, Sattin RW, Tinetti ME, Wolf SL: The effects of exercise on falls in elderly patients: a pre-planned meta-analysis of the FICSIT trials: frailty and injuries: cooperative studies of intervention techniques. *JAMA* 273:1341–1347, 1995
27. Nilsson P, Berglund G: Prevention of cardiovascular disease and diabetes: lessons from the Malmo Preventive Project. *J Intern Med* 248:455–462, 2000
28. Geiss LS, Rolka DB, Engelgau MM: Elevated blood pressure among U.S. adults with diabetes, 1988–1994. *Am J Prev Med* 22:42–48, 2002
29. Rolka DB, Fagot-Campagna A, Narayan KM: Aspirin use among adults with diabetes: estimates from the Third National Health and Nutrition Examination Survey. *Diabetes Care* 24:197–201, 2001
30. Diabetes mellitus: a major risk factor for cardiovascular disease (Editorial). *Circulation* 100:1132–1133, 1999
31. Sowers JR, Lester MA: Diabetes and cardiovascular disease. *Diabetes Care* 22 (Suppl. 3):C14–C20, 1999
32. Boyle JP, Honeycutt AA, Narayan KM, Hoerger TJ, Geiss LS, Chen H, Thompson TJ: Projection of diabetes burden through 2050: impact of changing demography and disease prevalence in the U.S. *Diabetes Care* 24:1936–1940, 2001